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On the occurrence of two species of striped *Ichthyophis* Fitzinger, 1826 (Amphibia: Gymnophiona: Ichthyophiidae) from Mizoram, India

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Abstract

The occurrence of 2 ichthyophiid caecilians, *Ichthyophis khumzhi* Kamei, Wilkinson, Gower & Biju, 2009 and *Ichthyophis moustakius* Kamei, Wilkinson, Gower & Biju, 2009 in the state of Mizoram in northeast India is reported for the first time. These records significantly increase the known distribution range of these striped forms of *Ichthyophis* which were previously known only from their type localities in the state of Manipur.

Key words

Range extension; first record; caecilian.

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Introduction

Ichthyophiid caecilians from India are represented by 2 constituent genera—*Uraeotyphlus* Peters, 1880 which is restricted in distribution to the South Western Ghats and *Ichthyophis* Fitzinger, 1826 which is more widespread, inhabiting the mesic regions of peninsular India and the northeastern states (Gower et al. 2002, Wilkinson et al. 2007, Kamei and Biju 2016). Members of the genus *Ichthyophis* are provisionally divided into 2 non-monophyletic groups based on the presence or absence of a yellow lateral stripe which serves as a useful diagnostic character (Gower et al. 2002, Wilkinson et al. 2007). They are represented by 14 extant species in India out of which only 2 (*I. sikkimensis* Taylor, 1960 and *I. bombayensis* Taylor, 1960) are unstriped forms.

In the northeastern states of India, the genus *Ichthyophis* is represented by seven striped form species (*I. alfredi* Mathew & Sen, 2009; *I. daribokensis* Mathew & Sen, 2009; *I. garoensis* Pillai & Ravichandran, 1999; *I. khumhzi*; *I. moustakius*; *I. nokrekensis* Mathew & Sen, 2009; *I. sendenyu* Kamei, Wilkinson, Gower & Biju, 2009), while *I. sikkimensis* Taylor, 1960 is the only unstriped form (Kamei and Biju 2016). *Ichthyophis husaini* Pillai & Ravichandran, 1999, until recently misidentified as an unstriped form, was relegated into the synonymy of *I. garoensis* based on morphological examination (Kamei and Biju 2016).

All recently described species of *Ichthyophis* from the northeastern states of India are known hitherto only from their respective type localities (Mathew and Sen

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2009, Kamei et al. 2009). Herein, we report the first records of *I. khumzhi* from Saiha district (22°22′28.0″ N, 092°56′06.1″ E) and *I. moustakius* from Sawleng Village in Aizawl district (23°58′40.6″ N, 092°55′35.4″ E) from the state of Mizoram.

Methods

We studied a collection of 22 specimens of striped form *Ichthyophis* spp. from Mizoram, India, collected over a period of 2 years from 2008 to 2010. Specimens were collected in accordance with permit number A.33011/2/99-CWLW/225 issued by the Chief Wildlife Warden, Environment, Forest and Climate Change Department, Government of Mizoram, India. These specimens were fixed in a 4% formaldehyde solution for 2 days, washed and transferred for preservation in 70% ethanol. All specimens have been deposited in either the Bombay Natural History Society (BNHS) or at the National Centre for Biological Sciences (NCBS), Bangalore, India.

All measurements were taken to the nearest 0.1 mm using a Mitutoyo™ dial vernier caliper except total length, which was measured using a thread and a ruler scale. The following abbreviations for external morphological characters were adopted for the sake of brevity (Table 1): AG = number of annular grooves counted dorsally; TL = total length; CM = corner of mouth; TN = distance between tentacle and nare (TN); TE = distance between tentacle and eye (TE); C1 = length of the first collar; C2 = length of the second collar.

Results

The descriptions and identification of all the nominate species of *Ichthyophis* from northeast India have thus far been solely based on morphological characters (Taylor 1960, Pillai and Ravichandran 1999, Mathew and Sen 2009, Kamei et al. 2009). Our morphological analyses of freshly collected specimens from Mizoram reveal the occurrence of at least 2 distinct species. Two specimens used in our study were identified as *I. khumzhi* and 2 more as *I. moustakius*. The other specimens could not be diagnosed with certainty based on our current understanding of the taxonomy and distributions of *Ichthyophis* spp. from northeast India. While *I. khumzhi* is distinct from all its northeast Indian congeners in terms of the number of annular grooves counted dorsally (AG), *I. moustakius* differs from the rest in possessing a unique moustache-like arched yellow stripe that extends beyond its tentacles coupled with the number of annular grooves on its body (Kamei et al. 2009). All nomenclature herein follows the taxonomy suggested by Kamei et al. (2009).

Both *I. khumzhi* and *I. moustakius* are distinguished from *I. sikkimensis* by the presence of a yellow lateral stripe.

Ichthyophis khumhzi is diagnosed from all other striped form congeners from northeastern India based on the number of annular grooves counted dorsally: 341–362 AGs vs 269–299 (*I.alfredi*), 264–310 (*I. daribokensis*), 269–300 (*I. nokrekensis*), 282–287 (*I. garoensis*), 238–268 (*I. moustakius*) and 283–308 (*I. sendenyu*) ; a distinct V-shaped head (Fig. 1C) tapering substantially after the TAs; C1 visibly shorter than C2 (Fig. 1D); TN/TE ratio

Table 1. Measurements (in mm) and meristic data for the specimens from Mizoram. Abbreviations as mentioned in materials and methods.

Species	***Ichthyophis khumzhi***		***Ichthyophis moustakius***	
Tag	NCBS 5385	MZMU A104	NCBS 5389	NCBS 5401
Total length	369.2	380	226.5	182.3
AG	353	351	265	266
T–E	2.3	1.9	1.4	1.4
T–N	5.5	4.5	3.1	2.9
TN/TE	2.39	2.37	2.21	2.07
Number of tail annuli	5	5	6	6
Width at midbody	17.3	16.9	8.9	9.7
Maximum width of stripe at midbody	2.4	2.5	2.9	1.9
Head length	17.9	14.8*	10.7	10.2
Length of C1 behind CM	3.2	3.6	2.3	2.7
Length of C2 behind CM	4.6	*	3	2.6
Distance between eyes	7.3	6.9	5.3	5
Distance between nares	2.5	2.2	1.7	2
Distance between eye and naris	6.9	6.7	4.3	4
Distance between TAs	7.7	7.5	5.2	5.2
Distance between TA and ST	6.7	6.2	4.2	4.4
Distance between TA and lip	0.6	0.4	0.5	0.2
Distance between ST and eye	7.9	7.7	5.3	5
Distance between ST and naris	1.4	1.4	1.4	1.3
Distance between eye and lip	1.8	1.4	1.2	0.9

* Measurement inaccurate or unavailable due to damage to the specimen.

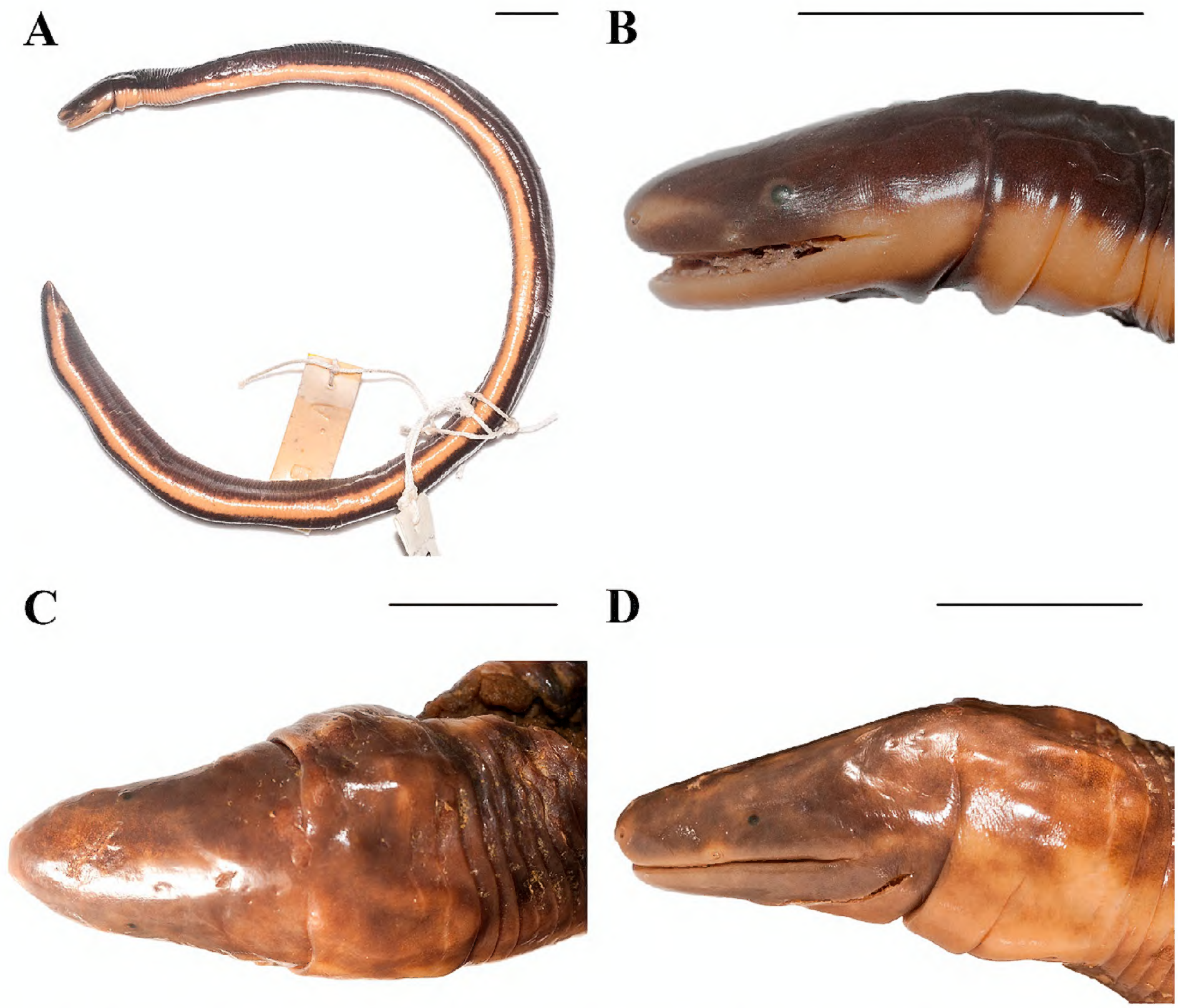

Figure 1. *Ichthyophis moustakius* and *I. khumzhi* from Mizoram, India. *Ichthyophis moustakius* (NCBS 5389), Sawleng, Mizoram: (**A**) lateral full-body view; (**B**) lateral view of head showing the arched yellow stripe between the nares and TAs. *Ichthyophis khumzhi* (NCBS 5385), Saiha, Mizoram: (**C**) dorsal view of head of showing a distinctive V-shape; (**D**) lateral view of head showing a visibly smaller C1 when compared with C2. Scale bars = 10mm.

2.2–2.4; narrow, irregular lateral stripes with uneven edges extending from close to CM to level of vent.

Ichthyophis moustakius is diagnosed using the following combination of characters: 238–268 AGs vs 282–287 (*I. garoensis*) and 283–308 (*I. sendenyu*); arched yellow stripes extending between nares and TAs, broader at the TAs (Fig 1A, B) vs no arched yellow stripes on head (*I. alfredi*, *I. daribokensis, I. nokrekensis*); U-shaped head tapering only slightly after the TAs; C1 and C2 of similar lengths; TN/TE 1.9–2.3; fairly regular, solid lateral stripes extending until CM.

The lack of fine-scale sampling efforts and genetic data combined with a paucity of robust morphological characters for *Ichthyophis* from northeastern India inhibit our ability to identify the other specimens in our collection from Mizoram. Kamei et al. (2009) described *I. khumzhi* based on 3 specimens collected from a single locality. We observed numerous specimens in our collection with the characteristic V-shaped head, coupled with a few other morphological characters, descriptive of *I. khumzhi*. However, the AGs of these specimens do not conform to the range published for *I. khumzhi* (364–396 vs 341–362). Similarly, Kamei et al. (2009) described *I. moustakius* with 238–268 AGs in their summary table, but their morphology datasheet includes 2 specimens (out of eight) with 272 and 292 AGs respectively. Taking a conservative approach, we employed the narrower AG range to diagnose *I. moustakius*, thereby excluding a lot of possible conspecifics from the scope of this report.

Discussion

The reports of *I. khumzhi* and *I. moustakius* present new state records for Mizoram. They also extend the geographical distribution range for *I. khumzhi* by 280 km and that of *I. moustakius* by 125 km south of their type localities (Fig. 2). All ichthyophiid species from northeastern India are categorized as Data Deficient or are not assessed (IUCN 2016). A comprehensive study employing molecular and morphological analyses of

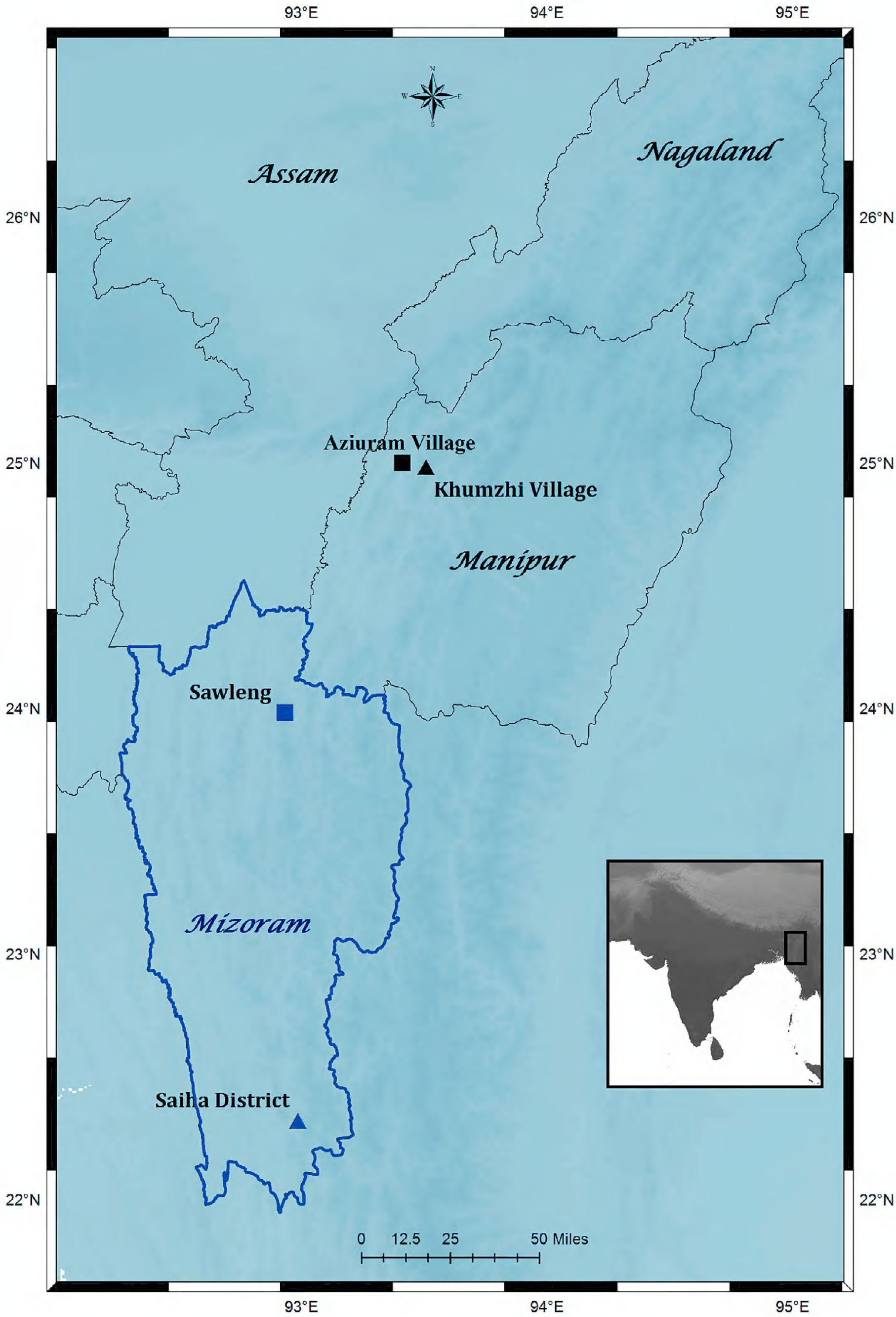

Figure 2. Map showing new localities for *Ichthyophis khumzhi* (blue triangle) and *I. moustakius* (blue square) and their type localities (black triangle and black square, respectively). The outline of the state of Mizoram is highlighted.

these cryptic amphibians would go a long way in helping assess their diversity, distribution and conservation statuses with better accuracy.

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Authors' Contributions

RC collected data, wrote the paper and made the map. HTL collected the specimens with due permits and wrote the paper, VG made the images for the plate and assisted in writing the paper.

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